Design Criteria for the Control of Health Hazards in Schools

SECOND EDITION

Occupational Health Safety Compensation

The Occupational Hygiene Branch is pleased to have sponsored the production and publication of this booklet. This is the revised edition which has several changes and additions over the first printing. This was done to correct errors and address new health concerns in schools.

It is hoped that this publication will assist in the recognition of potential health hazards associated with the changing use of school facilities in response to new programs of instruction. The booklet is intended for use by persons responsible for the planning and design of school buildings and the upgrading of existing facilities. It should also be of value to teachers and instructors in indentifying health hazards associated with their particular curricula.

Requests for further copies of this booklet, or additional information, should be addressed to this Branch.

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Design Criteria for the Control of Health Hazards in Schools

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Preface

During the early part of 1978, various meetings were held between the Occupational Hygiene Branch (formerly part of Alberta Labour and now with the Occupational Health & Safety Division of Alberta Worker's Health, Safety & Compensation) and the School Buildings Branch and Curriculum Branch of Alberta Education. The purpose of these meetings was to study the problems associated with the coordination of design approval for school facilities in the areas of Science, Vocational, Industrial and Fine Arts. Poor design of both new and old facilities gave teachers unhealthy working conditions and necessitated the costly upgrading of the ventilation, lighting and acoustical treatment in many schools.

The School Buildings Branch, Alberta Department of Education, has established the "Code Requirements" section under the Building Quality Restoration Program (1979-83) to allow funding for correction of the breaches in Alberta Occupational Health and Safety Regulations.

The general lack of information on the design needs for specific areas necessitated the production of a set of guidelines for people involved at the planning stage. In researching the material for this text, teachers and maintenance engineers throughout the province made valuable contributions. Dozens of schools throughout the province were visited and all the occupational hygiene reports reviewed. Contact was made with all the Departments and Ministries of Education across Canada and literature reviews were undertaken. The research results reinforced the need for a set of design guidelines.

The guidelines include a general section on hazard control systems and give requirements and recommendations for specific areas. For more detailed information a list of useful references is included.

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Introduction

Schools today increasingly resemble our industrial society and in consequence potential occupational health and hygiene problems arise. Modern school curricula are moving away from purely academic content. Today they commonly include not only pure science in laboratories, but also a host of other activities in the areas of industrial and fine arts.

Over the past few years there have been an increasing number of questions from teachers and secretarial staff who have concerns about occupational exposures to such things as dusts, chemicals, solvents, fumes, noise and heat.

In response to these queries, the Occupational Hygiene Branch of the Occupational Health & Safety Division has undertaken numerous surveys of schools throughout the Province. From these surveys it has become apparent that there is a need for guidelines for the control of hazards in the school environment. Even in new schools the design of control systems is not always appropriate for the hazards encountered. This manual intends to provide basic engineering design guidelines for ensuring a healthy working environment and should be of assistance in the planning of new school facilities or the upgrading of old ones. It concentrates on those areas in schools where potentially hazardous conditions are most often encountered. It does not deal with other control methods available such as personal protection and product or process substitution.

Engineers and Occupational Hygienists in the Occupational Hygiene Branch can give further information on design methods and standards relating to health hazards. In addition they can advise on the Chemical Hazards Regulation which sets the Occupational Exposure Limits for chemicals in workroom air. Safety related problems and requests can be directed to one of the offices of the Occupational Health and Safety Inspection Branch. Offices are located in Edmonton, Calgary, Grande Prairie, Red Deer, Fort McMurray, Medicine Hat and Lethbridge. Occupational Health & Safety Libraries located in the Edmonton and Calgary offices keep a comprehensive collection of books, journals, pamphlets and articles on occupational health & safety, including the references mentioned in thee guidelines.

Health Hazards Control

Both staff and students may be exposed to a mixture of a large number of chemical substances and physical agents during a school year and, consequently are at risk from known and potential hazards. It must be realized that current information regarding toxicity and control standards for industry is based on the exposure of adults in good health. It is important to note that the physiological defences of younger students are not fully developed, and this may make them more susceptable than adults to toxic materials.

The table below lists hazards commonly found in schools.

In order to provide a healthier working environment, the hazardous or potentially hazardous situations must first be recognized, carefully evaluated, and if necessary, the appropriate control system designed.

Many health hazards can be effectively controlled using appropriate engineering design. This will not necessarily afford adequate protection if other aspects are not taken into consideration. Awareness of potential hazards and safe handling procedures through education is of paramount importance. The use of personal protective equipment will in many cases substantially reduce exposure. Substitution by a less toxic compound is another effective way of controlling some health hazards.

TABLE 1

WORK AREA	SOLVENT VAPOURS	NOISE LEVELS	CHEMICALS	DUST
Plastics	✓		✓	✓
Fine Arts	✓		✓	✓
Duplicating & Printing	✓	✓	✓	
Beauty Culture	✓		✓	
Music Rooms		✓		
Science Labs	✓		✓	

Ventilation

Ventilation is one of the most important engineering control techniques available for limiting the release of contaminants into the air. Gases, vapours, mist, hot air, odours or dust may be unavoidable by-products of many processes and operations performed in schools. Excessive exposure to contaminants may impair the health of teachers and students.

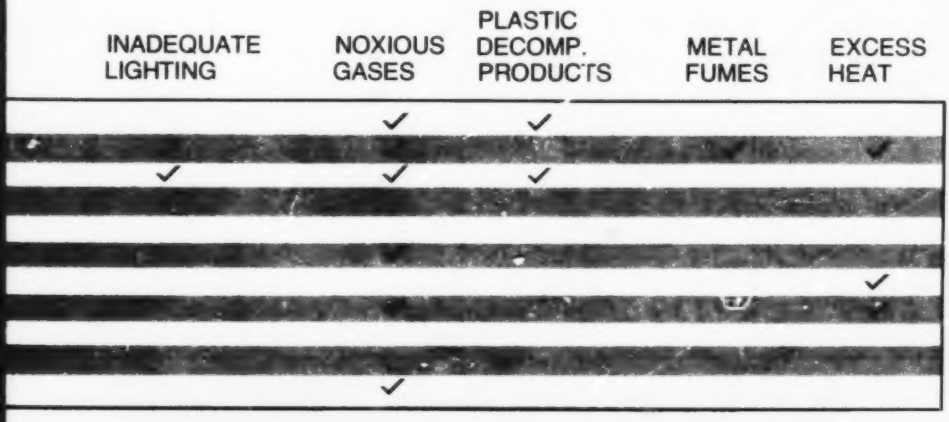
To achieve maximum effectiveness and economy, a ventilation system must be designed to meet the needs of each specific operation or process. There are two basic types of ventilation: general and local.

General Ventilation

The term general ventilation is synonymous with dilution ventilation, and refers to the dilution of contaminated air with fresh, clean air in a general area or room for the purpose of reducing the concentration of contaminants. Dilution will also control nuisance problems such as heat and odours.

General ventilation is designed to replace all the air in a building or room with fresh air several times per hour. The number of air changes necessary can vary from three per hour for classrooms to twelve per hour for photographic darkrooms.

Calculations for the number of air changes per hour are based on a standard ceiling height of 3.65 metres (12 feet). For each roomful of air exhausted, an equal amount of make-up air must be supplied to the room. The air must be tempered to provide a comfortable environment. The increasing energy costs



of heating and cooling air make general ventilation an expensive choice for controlling air contaminants.

Dilution ventilation is usually not as satisfactory for contaminant control as local exhaust ventilation since general ventilation is not very efficient in removing localized airborne contaminants. Any contaminant is usually well mixed with the air before being exhausted and students will receive some exposure. Also, contaminants travelling with the air from the point of origin to the exhaust vents will expose everyone along the path to some extent. General ventilation is not recommended for highly toxic materials.

Local Exhaust Ventilation

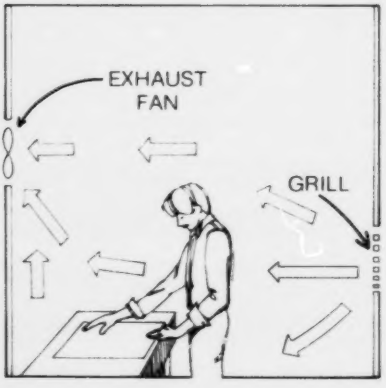
Local exhaust ventilation is the preferred method for controlling the work environment because this system captures the air contaminants at the point of generation. With this type of ventilation, the required exhaust volume of air is less than that for a general ventilation system and lower exhaust volumes may represent savings in both capital investment and air tempering cost. Unlike general ventilation, local exhaust ventilation can be switched off when not required.

General Principles of Local Exhaust Ventilation

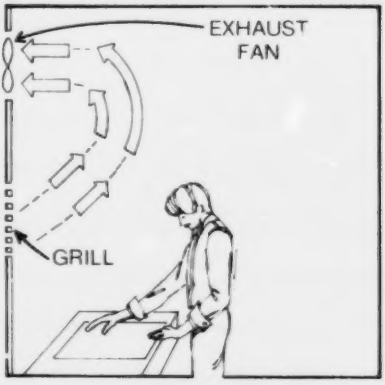
When designing a local exhaust ventilation system, the following principles should be taken into consideration:

- The exhaust fan should, wherever practicable, be located

GOOD AND POOR GENERAL VENTILATION



GOOD



POOR

downstream as close as possible to the exhaust discharge outlet and preferably outside the building. This will place the entire exhaust outlet under negative pressure and any air leakage will be into the system. Dust collectors, if necessary, should be placed before the fan so as to filter the air and minimize corrosion, abrasion or particle build-up on the fan blades.

- The hood should enclose the contaminant source as completely as possible and should be positioned to prevent the contaminants from reaching the operators' breathing zone.

- The air velocity at the hood entrance must be sufficiently high to capture the c inated air. The ability to capture contaminants falls off dramatically with distance from the hood entrance. The capture velocity at a distance equivalent to one duct diameter away from the exhaust opening may be reduced to about 10% of the velocity at the face opening.

- Any exhausted air containing toxic gases, fumes or allergenic dusts cannot be recirculated back into the work place. Recirculating ventilation systems are allowed in some woodworking shops but must receive approval from the Director of the Occupational Hygiene Branch before installation.

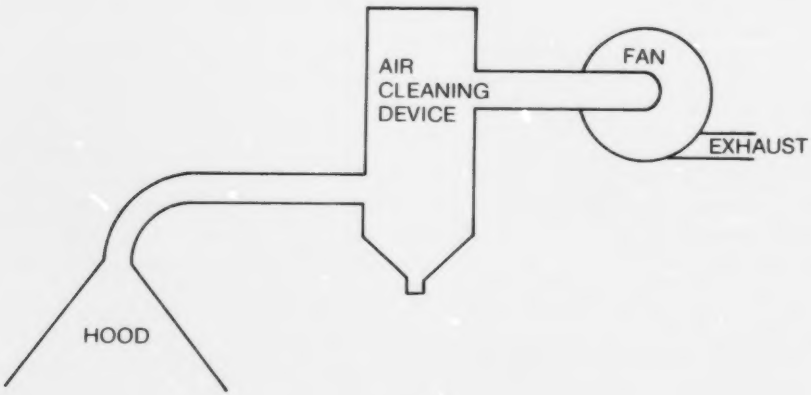
- Care should be taken to place exhaust air ducts outside the building away from air inlet systems to prevent re-entry of contaminants into other work areas.

- Any unnecessary elbows and entries should be avoided. When designing a duct layout, the shortest run of ducting should be used. This will minimize friction losses and result in a more efficient ventilation system. Long radius elbows and tapered entries should be used wherever needed.

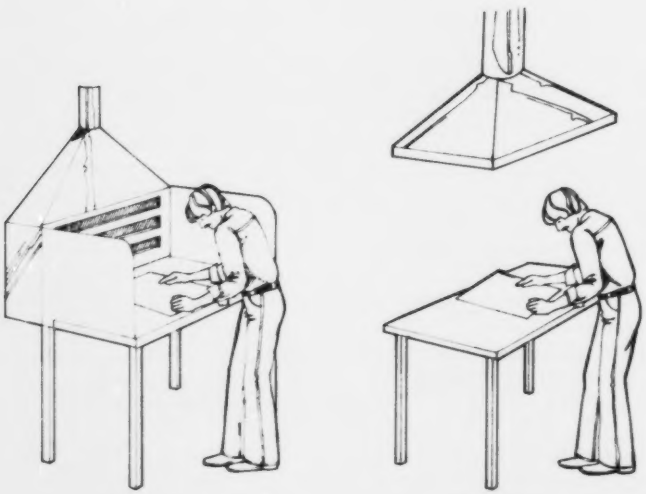
- A high air velocity must be maintained for effective transport of solid particles through ducts or the particles will settle to the bottom or collect on the walls of the duct. For example, woodworking operations need a duct transport velocity of 20 metres per second (m/s) (4000 fpm).

- Whenever a new local exhaust ventilation system is installed, the performance should be measured and evaluated to ensure the system meets design specifications. A static pressure gauge indicates air flow and should be installed close to the suction end of the exhaust fan. This will allow for periodic performance checking of the system. A static pressure variation of 20-30 percent from normal working pressure indicates that the system needs to be checked. These gauges are readily installed, easily read and inexpensive.

EXAMPLE LAYOUT OF A LOCAL EXHAUST SYSTEM



GOOD AND POOR USE OF LOCAL VENTILATION



GOOD POOR

Make Up Air

Allowances must be made for the replacement of air exhausted from a room or building. Inadequate make up air causes negative pressure and creates many problems including inefficient operation of exhaust fans. Fresh air must be supplied in an amount at least equal to the designed exhaust capacity of the ventilation system.

Provisions should be made to temper the incoming air. In some cases, multiple ceiling grills and slow diffusion of cold air into a thermostated room is acceptable. Make up air discharge grilles should be positioned to avoid short circuiting by exhaust ducts or hoods.

Woodworking

Prolonged exposure to wood dust may result in lung problems. Some woods, such as mahoganies and cedars, may cause allergenic reactions. Appropriate local exhaust ventilation is required on woodworking machinery to reduce the health hazard and promote good housekeeping.

The following design guidelines for woodworking shops should be taken into account:

- Exhausted air from woodworking machines using chemically treated or allergenic woods cannot be recirculated and must be exhausted to the outside. Cyclones, filters, bag collectors and other particulate collectors will not remove the allergy-causing chemicals from the air. Recirculatory systems are only allowed in certain instances and must receive approval from the Director of Occupational Hygiene.

- The dust collecting hood on each machine must be designed to effectively capture generated dust. Hood design should take full advantage of particle momentum. A very helpful reference for good hood and exhaust design is the ACGIH. "Industrial Ventilation Manual". This manual describes appropriate hoods for many types of woodworking operations and the recommended air velocities needed to capture wood dust. The Occupational Health and Safety Division has a document entitled "Woodworking Exhaust Ventilation Requirements for Industrial Art Areas in Alberta High Schools". It is available from the Occupational Hygiene Branch and lists the recommended exhaust volumes for woodworking machinery.

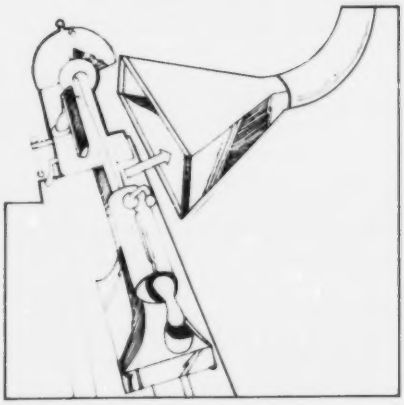
- Effective dust transport through ducts requires high air velocities. Typically main ducts must have a minimum air velocity of 17.8 m/s (3500 fpm) and branch ducts must have 20 m/s (4000 fpm). Inadequate exhaust velocities and unnecessary elbows and bends may lead to frequent blockages in the exhaust ducts.

- Overhead ducting is usually more flexible for future modifications

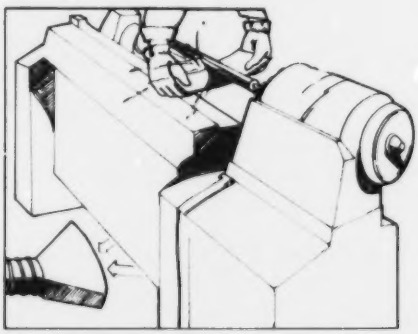
and easier to service than under-floor ducting.

- The exhaust ducting should be attached directly or by a short flexible hose of durable nature to the dust collecting hood on the woodworking machine.
- Flexible hoses should be kept as short as possible in order to avoid unnecessary friction losses in the exhaust system.
- The layout of an exhaust system should be carefully planned to give maximum flexibility for future expansion.
- When exhausting air from an area, ensure that the appropriate amount of make up air is supplied.
- In order to maintain noise levels at an acceptable level and reduce the explosion and fire hazard, the cyclone or dust collector should be located in a separate room or outside the building.
- The ducts used for floor sweeps should have a grill to prevent large pieces from clogging the duct work.

A POOR HOOD DESIGN FOR A LATHE



A GOOD HOOD DESIGN FOR A LATHE



Metal Working

Welding, cutting, soldering, brazing, plating and the use of small furnaces may produce large volumes of toxic gases and fumes. A local exhaust system is the best way to control the release of air contaminants from metal working operations.

For small operations, ventilated hoods and tables may be used to partially enclose and extract fumes. The local exhaust should be positioned in the booth to remove the contaminants from the welder's breathing zone. Canopy hoods placed over the welders' heads are inadequate because fumes are drawn past the breathing zone before being exhausted. Also, an enclosed booth for arc-welding will reduce arc flash to the rest of the room.

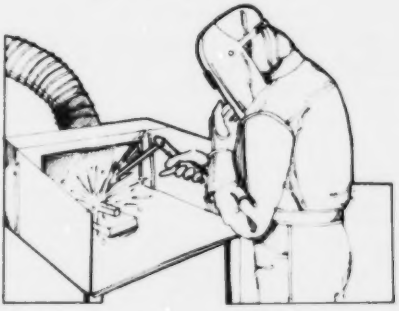
- Fumes from large jobs are best controlled by the use of a flexible local exhaust system. A series of arms or pulleys allow the exhaust hood to be positioned by the welder at the weld. This system will give good control with the flexible hose attached to a flanged rectangular hood. This system needs to have a minimum capture velocity of 0.5 m/s (100 fpm).

- In addition, the metal working area must be provided with general ventilation. There should be a minimum of three to six air changes per hour in the shop.

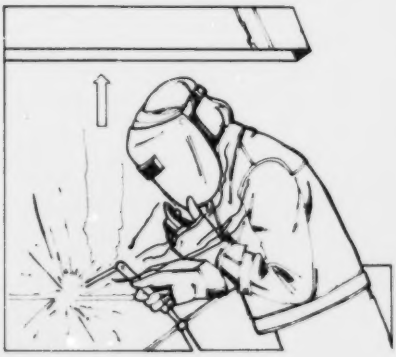
- Where it is impractical to use local exhaust ventilation, general ventilation with the capacity of 1 m^3/s (2000 cfm) per arc welding unit may be used. This is permissable if only mild steel or iron welding is done.

- Welding fumes and gases must be exhausted and cannot be recirculated into the work area.

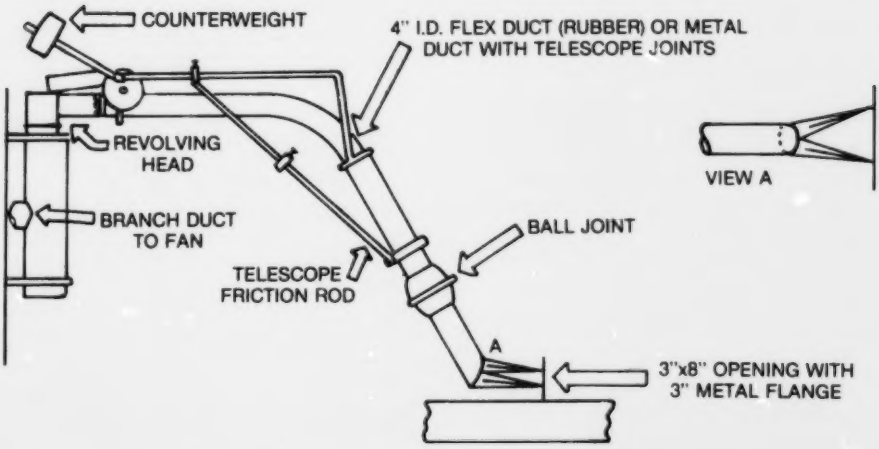
A WELL DESIGNED WELDING HOOD



A POORLY DESIGNED WELDING HOOD



AN EXAMPLE OF A FLEXIBLE LOCAL EXHAUST SYSTEM



Automotives

Tune-Up Areas

Automobile exhaust gases contain significant quantitities of carbon monoxide as well as other toxic substances. Carbon monoxide is odourless, colourless and tasteless. The irritating gases and smoke that often accompany engine exhaust cannot be relied upon for adequate warning of hazardous conditions.

Shops intended for automotive tune-ups and engine repair must be provided with a local exhaust system to remove gases directly from the automobile tail pipes through flexible hoses. This system must be designed to exhaust at the rate of 0.05 cubic metres/second (m^3/s) (105 cfm) per outlet for cars, 0.1 m^3/s (210 cfm) per outlet for trucks and 0.2 m^3/s (420 cfm) per outlet for diesel trucks.

Proper adapters should be used to connect the local exhaust system to the engine exhaust to minimize the release of exhaust gases into the room. The flexible hoses should be at least 7.5 cm (3 in.) in diameter for cars, 210 cm (4 in.) for trucks and 420 cm (4.5 in.) for diesel trucks. The hoses should be as short as possible.

Small Engine Repairs

Each small motor, such as lawn mowers, must be connected to a local exhaust system having an exhaust capacity of 0.023 m^3/s (50 cfm).

If the motor running area is self-contained or in a small room, general ventilation giving from three to six air changes per hour must be provided as well.

Vehicle Repair Pits

Sufficient ventilation must be supplied to dilute flammable vapours, smoke or gases below hazardous levels. Adequate ventilation is achieved by supplying fresh air at a minimum rate of 0.005 m^3/s for each square metre of pit floor area (1 cfm/ft^2). The point of supply must not be higher than 0.30 m (1 ft.) above the floor level of the pit.

Spray Painting

Spray painting operations must be carried out in a well ventilated booth or hood.

The hazards of spray painting are two-fold: an **explosion** hazard which must be minimized by installing explosion-proof motors, electrical wiring, lights and fans, and a **health** hazard due to the inhalation of solvents, pigments, resins and hardeners. Personal respiratory protection in addition to adequate ventilation, must be used to provide protection.

For large booths, such as those used to paint automobiles, air must be exhausted at a rate of 0.023 m^3/s per square metre cross sectional area of booth (50 $cfm/ft.^2$). Proper personal respiratory protection must be worn inside the booth while spray painting.

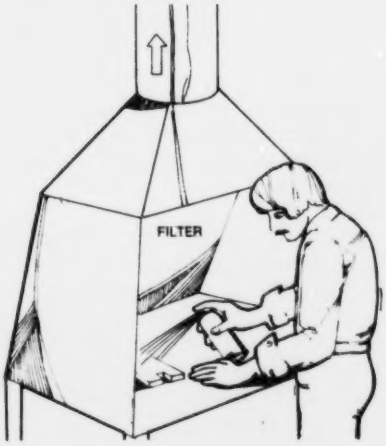
Smaller booths, such as illustrated, should be deep enough to prevent any over spray entering the classroom atmosphere. A fan exhausting 0.07 m^3/s per square metre cross sectional area of booth (150 $cfm/ft.^2$) should be installed.

An effective filtration system for removing paint overspray and solvent vapours from the exhausted air is a water wash which consists of a sheet of falling water. However, if the booth is small or is only in intermittent use, then a dry filter system of fibreglass mats could be used. The air exhausted from the booth cannot be recirculated.

The recommended sizes for walk-in spray booths are:

Width = Work Size + 2 Metres
Height = Work Size + 1 Metres
Length = Work Size + 2 Metres

A SMALL VENTILATED HOOD IN USE



Storage of Volatile Substances

Volatile substances have a variety of uses in schools. They can range from chemicals in the science laboratories to thinners, paints and laquers in the arts section. Inhalation and skin contact with volatiles may be hazardous to health.

Many of these materials are purchased in large quantities and the absence of proper storage facilities may result in the accumulation of large amounts in different locations. The fire hazard and unnecessary exposure can be minimized by limiting the amounts of materials in the work area to a few days or weeks supply. The remainder should be stored in a properly designed central location.

General ventilation in the central storage area should exhaust 0.005 m^3/s per m^2 of floor area (1 cfm/ft^2). the exhaust stack outside the building should be located at a point remote from air intakes.

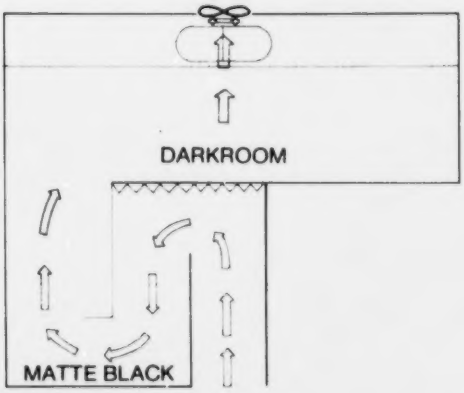
Photographic Darkrooms

Many of the chemicals used in photographic processes may cause irritation of the mucous membranes and skin. Inhalation of the vapours may, in some cases, cause lung problems. Generally, the chemicals used for colour developing are more toxic than those used for black and white developing.

The following points must be considered when designing a dark room:

- There must be a ventilation system installed providing 10 air changes per hour for black and white developing. The fan must be placed in a location to draw the contaminants away from the students' breathing zone.
- Colour developing chemical trays must be locally exhausted by a side drafted hood. The hood should exhaust at the rate of 0.75 m^2/s per square metre surface area (150 cfm/sq. ft.) of the trays.
- All the exhausted air must be vented to the outside of the building and none of the air can be recirculated.
- Adequate make up discharge grilles must be located in such a way as to sweep the room of contaminated air.

A DESIGN FOR A DARKROOM



Science Laboratories

Any science laboratory in which fumes and vapours are produced must have adequate ventilation as outlined below:

- Fume hoods should have a face velocity of 0.5 m/s (100 fpm) at the normal working opening.
- All fume hood fans, motors and electrical switches must be explosion-proof and corrosion resistant.
- Exhaust ductwork should be arranged so the fan is located outside the building. Ducts will then be under negative pressure and all leaks will be into the system, eliminating contamination of other rooms or the ceiling space.
- The area should be kept at a slight negative pressure to provide a slight indraft at doorways and confine any fumes to the laboratory.
- The general ventilation should provide 12 air changes per hour to ensure that air contaminant concentrations are maintained below the recommended limits. This is required in addition to the local exhaust systems in the area.

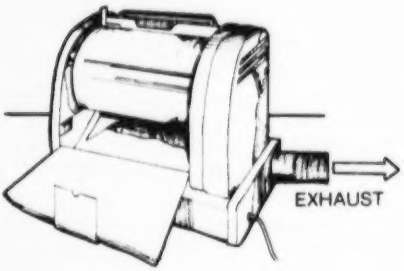
Duplicating Rooms

Duplicating and copying processes are often carried out in small unventilated rooms which may allow the operator to be unnecessarily exposed to solvent vapours. Best control is given by using local exhaust ventilation system capable of providing a capture velocity of 0.25 m/s (50 fpm) at the roller and freshly printed pages where solvent evaporation is taking place. Control may be best achieved by:

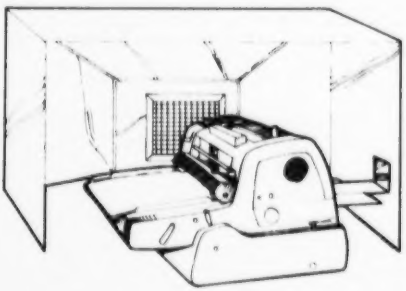
- Exhausting the solvent vapours directly from the machine. This will give best control of vapours from spirit duplicators. It is simple to install and exhausts only small amounts of air from the building.
- Placing the duplicator in a cross-draft ventilated cabinet.
- For large duplicating equipment, a canopy hood placed as close as possible to the top of the copier and recently printed pages, will control solvent vapour. The machine should be enclosed by walls or curtains on three sides to ensure effective air flow to remove air contaminants.

Spirit duplicator problems in Alberta Schools was detailed in the Occupational Health & Safety Bulletin entitled "Methanol Exposure from Spirit Duplicators", November 1977.

DUPLICATOR WITH DIRECT LOCAL EXHAUST VENTILATION



DUPLICATOR IN CABINET WITH LOCAL EXHAUST VENTILATION



Classrooms

When designing ventilation systems for classrooms, it is important to ensure that adequate fresh air is provided. ASHRAE guidelines for classrooms and changing rooms should be followed. General ventilation should provide a minimum of 0.004 m^3/m per occupant (10 cfm/occupant), of which 0.002 m^2/s per occupant (5 cfm/occupant) is fresh air.

Humidity may fall to very low levels in winter months. Lack of humidity causes sore throats, itchy eyes and skin. Classroom air should be between 20% and 50% relative humidity.

Changing Rooms

These rooms tend to be small, crowded and subject to odours. The general ventilation should provide 0.014 m^3/s/locker (30 cfm per locker) of which 0.002 m^3/s (5 cfm) is fresh air.

Fine Arts Area

Artists continually use new and untried materials, which may be hazardous. The majority of these materials contain volatile solvents or may form hazardous dusts and mists. The resulting airborne contaminants can be controlled using various forms of local exhaust ventilation. The Occupational Hygiene Branch has published a book detailing the hazards found in fine arts areas. This book is entitled "Health and Safety in Printmaking" and may be obtained from Alberta Government Services, Queen's Printer Building, 11510 Kingsway Avenue, Edmonton, Alberta, T5G 2Y5.

Plastics

Many of the processes used to fabricate plastics can be very hazardous. The degree of the hazard depends on the type of plastic and whether a student is making plastics or working with a finished plastic (as in heat molding, injection molding, vacuum forming, cutting, and sanding). Several of the substances produced are highly toxic. Curing agents such as methyl ethyl ketone peroxide are chemical sensitizers. The toxic nature of materials used in making plastics dictates the operation should be executed in a hood enclosed on three sides. The ventilation system must provide a minimum face velocity of 0.76 m/s (150 fpm).

Graphics

Any printing machine which is in frequent use and requires inks and solvents should have a hood providing 0.25 m/s (50 fpm) capture velocity.

Etching

All the acids used in this process are hazardous because they are strong irritants, especially in their concentrated forms. The mixing, as well as the etching, should be done under local ventilation to prevent inhalation of the acid mists. The trays should be placed in a backdrafted hood providing a minimum capture velocity of 0.5 m/s (100 fpm).

Silk Screening

The main hazard lies in the large amounts of solvents used in the inks, thinners, and general screen solvents. Airborne concentrations of solvents are usually high, so silk screening activities should only take place on a crossdrafted table. An overhead canopy hood should not be used as this will draw the vapours into the operator's breathing zone. The local exhaust ventilation should provide a capture velocity of 0.5 m/s (100 fpm).

Pottery and Ceramics

The health hazards in this area are dust from sanding and fumes generated during the firing of pottery.

Clays are silicates and may contain free silica. Inhalation of silica may produce silicosis; a debilitating lung disease. Mixing and sanding operations should only take place within local exhaust hoods providing 1.5 m/s (300 fpm) face velocity.

Glazes and colours may contain toxic substances such as lead or barium carbonate. The use of frits containing toxic materials decreases the hazard since they cannot be absorbed through the skin.

Toxic fumes and gases are produced during the firing process. Kilns must be vented to the outside by canopy hood providing a capture velocity of 0.25 m/s (50 fpm). A chimney may be used provided the kiln is enclosed on three sides.

Noise

Noise may be a problem in many areas of a school. An essential aspect of noise-control design is the establishment of acceptable noise levels for the space being acoustically treated.

The decibel, dB, is a logarithmic function and is a ratio of a measured pressure to a reference pressure. In acoustics, the reference pressure is 20 micropascals and this represents the faintest sound that a normal young ear can detect. The A network has a frequency discrimination similar to that of the human ear. A given sound measured on an A weighted network of a sound level meter is given in dBA. Noise levels that do not exceed 85 dBA during an eight hour day may be considered to exist at an annoyance level. Although this type of noise may disturb normal work habits it is not likely to cause hearing impairment and the controls needed to reduce it will not be considered in these guidelines.

In certain areas, hazardous noise levels may be reached. The hearing damage potential of noise depends not only on its intensity but also its duration and the frequency at which it occurs.

In general, high frequency sound is more damaging to the hearing mechanism than that of a low frequency. Constant exposure to high intensity noise levels (> 85 dBA) may lead to noise induced hearing impairment.

Occupational Exposure Limits

Occupational Exposure Limits for noise refer to the standards for sound levels and durations of exposure that are allowed in the Occupational Health and Safety Act - Noise Regulation. Allowed exposure to noise varies according to intensity and duration of exposure.

Occupational Exposure Limits For Noise

Sound Levels (dBA)	Maximum Permitted Duration (Hours Per Day)
80	16
85	8
90	4
95	2
100	1
105	1/2
110	1/4
115 max.	1/8

Design Controls

In excessively noisy areas, engineering controls should be attempted to reduce the noise to below the Occupational Exposure Limit. The following factors should be taken into consideration when applying engineering noise controls:

- Physical dimensions - Ceiling of less than 5.5 metres (18 ft.) in music room should not be considered if sound levels are to be reduced to acceptable levels.

- Location - Noisy areas should be located away from other areas such as classrooms or constructed with sound-proof walls.

- Acoustical treatment - Noise reductions of 3 - 5 dBA can be achieved by acoustically treating a room to eliminate reverberation build-up. Hard surfaces or walls and ceilings can increase reverberation and increase noise levels. If the noise comes from a machine, acoustical treatment of walls will not reduce the operator's exposure. The operator is in the near field of the noise and reverberation does not substantially increase his exposure. However, acoustical treating of a room will reduce the exposure of other people in that room.

- Vibration isolators - Wherever possible, machines and motors should be securely mounted on appropriate vibration isolators or flexible connectors to reduce noise levels. Cyclones should be connected to duct work by a short piece of flexible hose in order to reduce transmission of the vibrations through the duct work.

- Substitution - Substituting a quieter machine for a noisier one. If it is feasible, the offending machine may be removed by changing the course program.

- Equipment Maintenance - A rigid maintenance schedule should be enforced. For example, keeping planer blades sharp can substantially reduce the noise levels.

Music and Band Rooms

High sound levels may be a problem in band and music rooms. This is often due to poor design or the make-shift nature of band rooms. Hazardous exposures may be remedied by reducing exposure time or by correcting the design of the facilities. A document entitled "Sound Control in Band Rooms in Edmonton Public Schools" written by Mr. M. Fayers for the Edmonton Public School Board gives solutions to the problem.

- An average ceiling height of 6.4 to 9.1 metres (21-30 ft.) is desirable. Even a 6 metre ceiling seldom produces a volume of 17 m^3/student which is required to keep noise at a comfortable level. Heights of less than 6 metres should be considered only if sufficient floor space is provided to yield a volume in excess of 11.5 m^3/students. Anything less than 5 metre ceiling height in an instrumental rehearsal room should be seriously questioned.

- Rehearsal rooms should have a short reverberation time in order to reduce sound levels.

- The walls, ceiling and floor should have appropriate acoustical treatment. The ability of different

materials to absorb sound varies with the sound frequency. For example, brick will absorb low frequency noise more effectively than wood, and carpets absorb high frequency sound more effectively than low frequency sound.

- Some sound absorbents, such as glass fibre or polyurethane foam, will not greatly affect the transmission of sound through walls. Although these materials will reduce reflected sound within a room, they will do little to reduce sound transmitted to adjacent areas.

- Naturally, the amount of noise reduction that can be achieved is limited. It is not possible to reduce sound levels lower than could be obtained if there were no reflecting walls present in the music room.

- The following table is a guide to the relative effectiveness of various common building materials in absorbing reflected sound in the frequency range 500-4000 Hz:

Material	Percentage of Incident Sound Absorbed
Bricks	2 - 3
Thick wood	5 - 10
Drapes or thin carpet	20 - 40
Acoustical tile	70 - 95

Illumination

When designing lighting systems, equal consideration should be given to both the quantitative and qualitative aspects of illumination since they both have important implications for the health and safety of teachers and students.

Quantitative Aspects

The level of illumination depends on the task being performed. Each task has an optimum level of illumination and our standards are those of the Canadian Standards Association's "School Lighting Document".

Work-related errors tend to decrease as the level of illumination increases until an optimum is achieved. This optimum will vary with the age and visual acuity of the individual.

Qualitative Aspects

The factors involved in the quality of lighting include glare, diffusion, direction and uniformity of distribution, colour, brightness and brightness ratios, all of which have a significant effect upon visibility and the ability to see easily, accurately and quickly.

In general, fluorescent tubes lose 20-40% of their efficiency after 18-24 months of use. If the tubes are changed regularly the ballasts should last many years. Worn out ballasts emit a very annoying high frequency sound.

Sprayed-On Asbestos Containing Materials

The health effects from inhalation of asbestos are asbestosis, lung cancer and mesothelioma. Asbestosis is a debilitating lung disease and mesothelioma is cancer of the lining of the chest or abdominal cavity.

In the past, sprayed-on asbestos containing material has been used for fire proofing, insulating, acoustical and decorative material. Students and staff may damage the surface of the sprayed asbestos resulting in the release of fibres. An undamaged surface may not release asbestos fibres and this does not present a health hazard.

If a hazard exists in a school, there are three engineering methods available to control the release of asbestos fibres. They are stripping, enclosure and encapsulation. Each method has its own advantages and disadvantages.

Stripping involves the wetting, **complete** removal, collection and disposal of the sprayed-on asbestos containing material from the supporting surface. This method requires stringent control measures to prevent contamination of surrounding areas from airborne asbestos fibres. Also, finding a substitute material to fulfill the purpose of the asbestos must be considered.

Enclosure is using barriers, such as gypsum, plywood or metal walls, placed between the asbestos containing material and the building environment. Fibre generation and time involved may be less than for stripping. The barrier may restrict accessibility to wiring, plumbing, ventilation, etc. Incorrect material selection may alter the original purpose of the surface. For example, acoustic treatment may be changed by adding inappropriate barriers.

Encapsulation is coating the asbestos containing material with sealant which may penetrate or cover the surface. Sealants do not restrict fixture accessibility. It can be used in areas not suitable for stripping or enclosure. Before this method is effective, the asbestos containing material surface must be intact prior encapsulation. Physical abuse and possible degradation of the sealant over a period of time will decrease the control value of this method.

Only stripping will remove the asbestos from the building and eliminate any future problems. Asbestos is still present with the enclosure and encapsulation methods. Future building modifications might disturb the asbestos, causing a hazardous situation. All these factors must be taken into account when considering asbestos control. Recommended guidelines entitled, "The Control of Fibre Released From Sprayed-On Asbestos Containing Surfaces" are available from the Occupational Hygiene Branch.

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Glossary

A.C.G.I.H. - American Conference of Governmental Industrial Hygienists

Allergen - a substance causing an abnormal response in a hypersensitive person.

ASHRAE - American Society of Heating, Refrigeration and Air Conditioning Engineers.

Capture Velocity - air velocity at any point in front of the hood necessary to capture and remove air contaminants.

Chemical Sensitizer - A substance that is capable, upon contact, of inducing increasingly adverse effects upon a given individual; such effects are not limited by the area of contact.

Contaminant - A harmful, irritating or nuisance material that is foreign to the normal atmosphere.

Face Velocity - air velocity at the hood opening.

Fumes - Small solid particles created by condensation of vapours.

Irritant - A substance that produces a recognized irritating effect at the area of contact.

N.I.O.S.H. - National Institute for Occupational Safety and Health.

Vapour - The gaseous form of a substance.